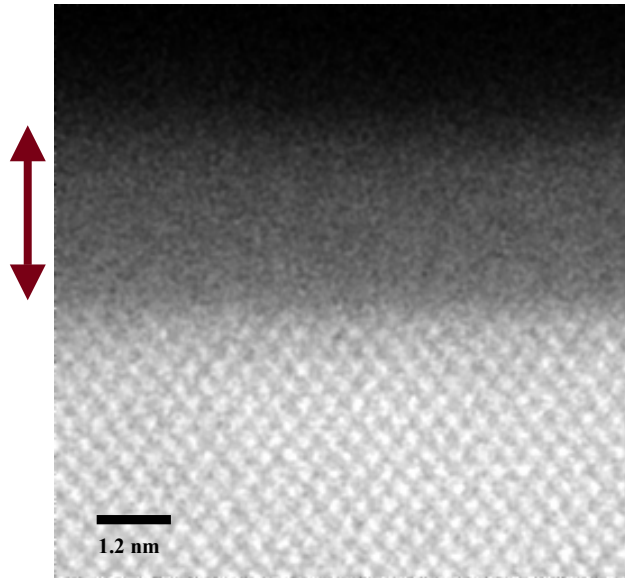
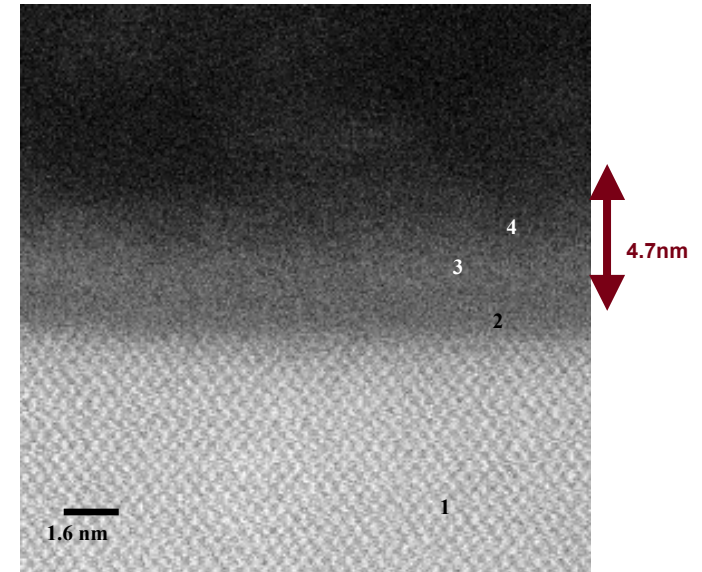


Interface Stability Issues in Novel High-K Dielectrics

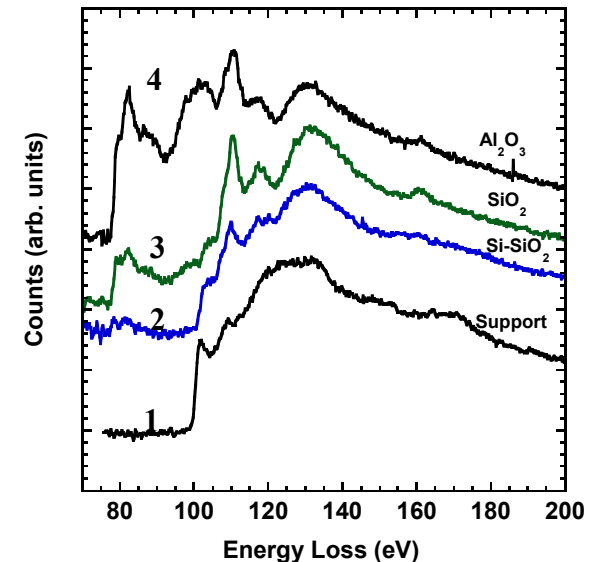
As-deposited Al_2O_3



In-situ
Heating

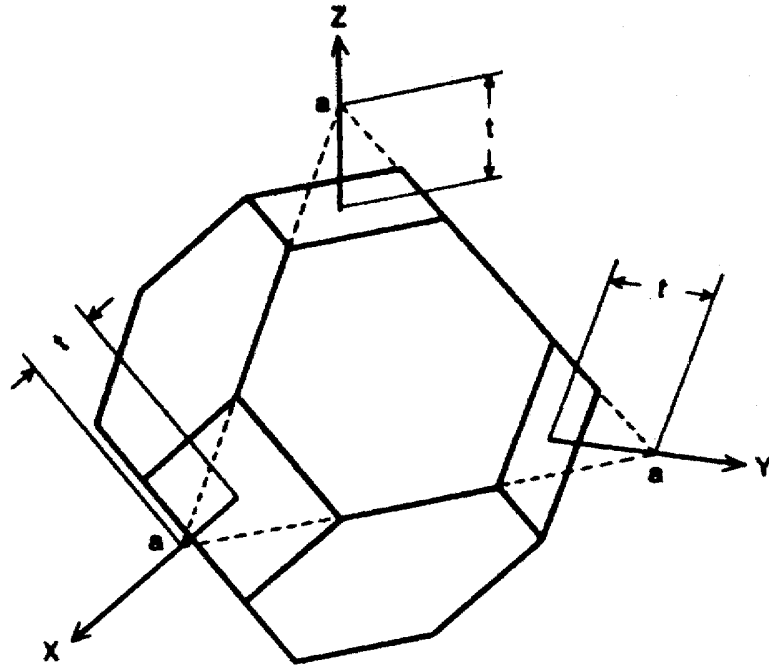


Interface Stability Reduced by
Excess Oxygen in Al_2O_3



The Oxidation of Si/Al₂O₃ Interfaces by Trapped Excess Oxygen; N. D. Browning/U. Illinois-Chicago; DMR 9733895. The end of the roadmap for SiO₂ as the gate oxide in Si based field effect transistors has led to a critical need for the development of new gate oxide material. Stoichiometric alumina (Al₂O₃) is one material that has been proposed to be a good candidate to replace SiO₂ as it has the necessary dielectric properties and is known to form a stable interface with Si. However, attempts to grow thin dielectric layers on Si has invariably resulted in the formation of a SiO₂ interlayer after annealing; thereby degrading overall performance. Unique atomic resolution in-situ analysis performed at UIC (in collaboration with C. Takoudis) has determined the origin of this effect to be excess oxygen trapped in the Al₂O₃ films during deposition. The left panel in the figure shows the as-deposited thin film of Al₂O₃ on Si. After heating in-situ in the microscope for a period of an hour the interface structure is seen to be modified. Electron energy loss spectroscopy (EELS) from the interface region shows that a SiO₂ layer has formed and the total thickness of this layer and the Al₂O₃ film is larger than the original as-deposited film. As the partial pressure of oxygen in the ultra-high vacuum conditions of the microscope is only $\sim 5 \times 10^{-8}$ Pa, the only place that this oxygen could have come from is the Al₂O₃ film itself. This result has been confirmed by FTIR and XPS analysis ex-situ and indicates that the composition of the as-deposited film plays a large role in determining the stability of the interface. Work is underway to investigate the effect of different deposition conditions on stability and develop a viable mechanism for deposition of thin alumina films on Si

Void Mediated Growth of Quantum Dots in the SnSi system

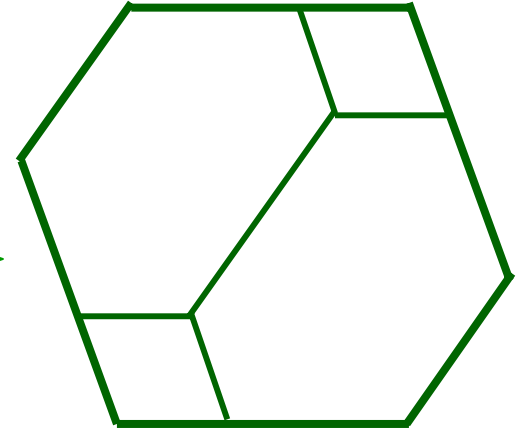


Equilibrium void shape in Si
is a tetrakaidecahedron

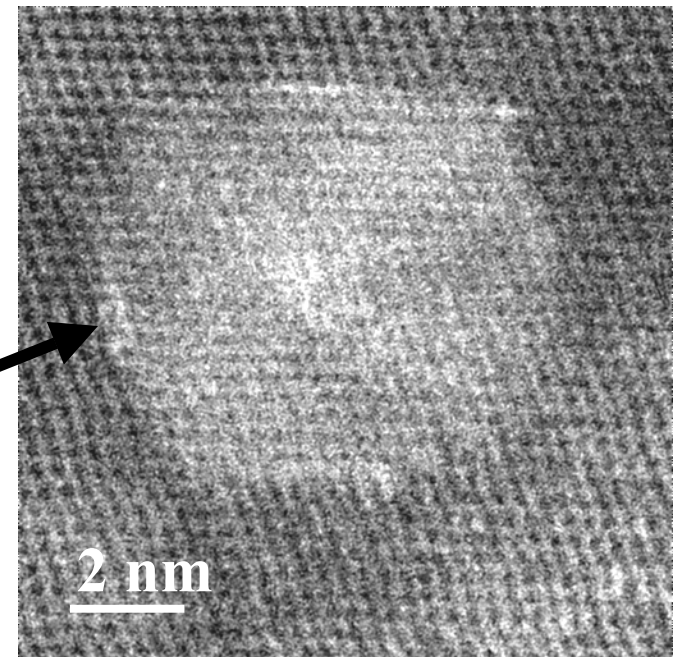
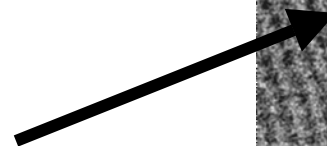
[110] projection of the



tetrakaidecahedron



Intensity indicates
Partial filling



Void Mediated Growth of Quantum Dots in the SnSi system; N. D. Browning/U. Illinois-Chicago; DMR 7733895. α -Sn (and α -Sn_xSi_{1-x}) quantum dots embedded in a Si matrix have many potential device applications in opto-electronic and thermo-photovoltaic devices. The large 19.5% lattice mismatch between Si and α -Sn and the low solid solubility (~.12%) currently limits the composition range that can be obtained and the morphology of the structures. The nucleation and growth mechanisms of these MBE grown quantum dots (grown by H. Atwater at Caltech) have been investigated using atomic resolution microscopic techniques. In particular it has been found that voids in the Si substrate that are induced by the deposition of the large lattice mismatched α -Sn act as segregation sites for Sn. During deposition and annealing, Sn diffuses into these voids (the equilibrium structure of which is shown in the left panel) to form the observed regularly shaped quantum dots. Z-contrast images of these quantum dot structures (right panel) show that the dots themselves have a range of Sn content that depends on the time duration of the anneal. The partial filling with Sn is confirmed by electron energy loss spectroscopy and in-situ annealing in the microscope, where the quantum dot structures (voids) are seen to increase in intensity (i.e. fill with Sn) as the anneal proceeds. Such analysis explains the observation of the rapid initial growth of quantum dots in this system. Work is continuing to address the coarsening mechanism and composition of the dots after nucleation with the aim of understanding the mechanisms needed to produce viable device structures.